Impact of Renewable Portfolio Standards on China's power sector

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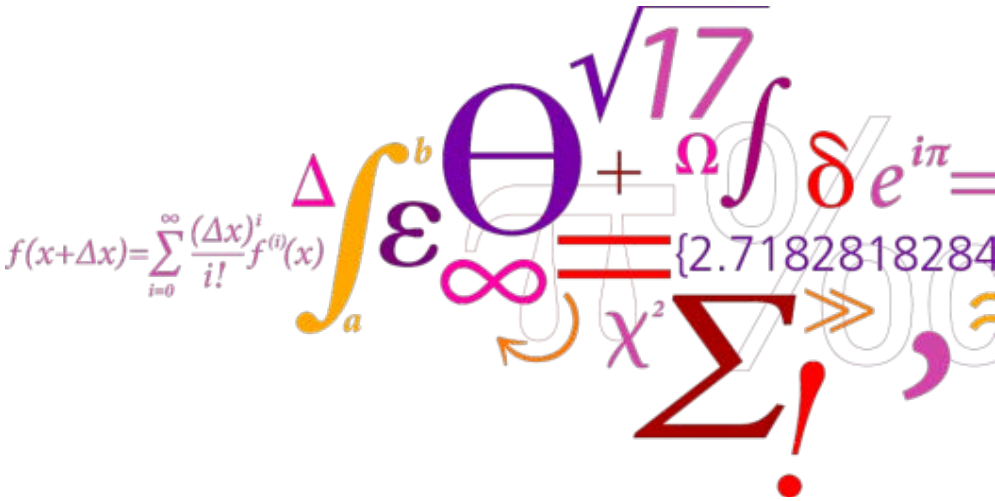

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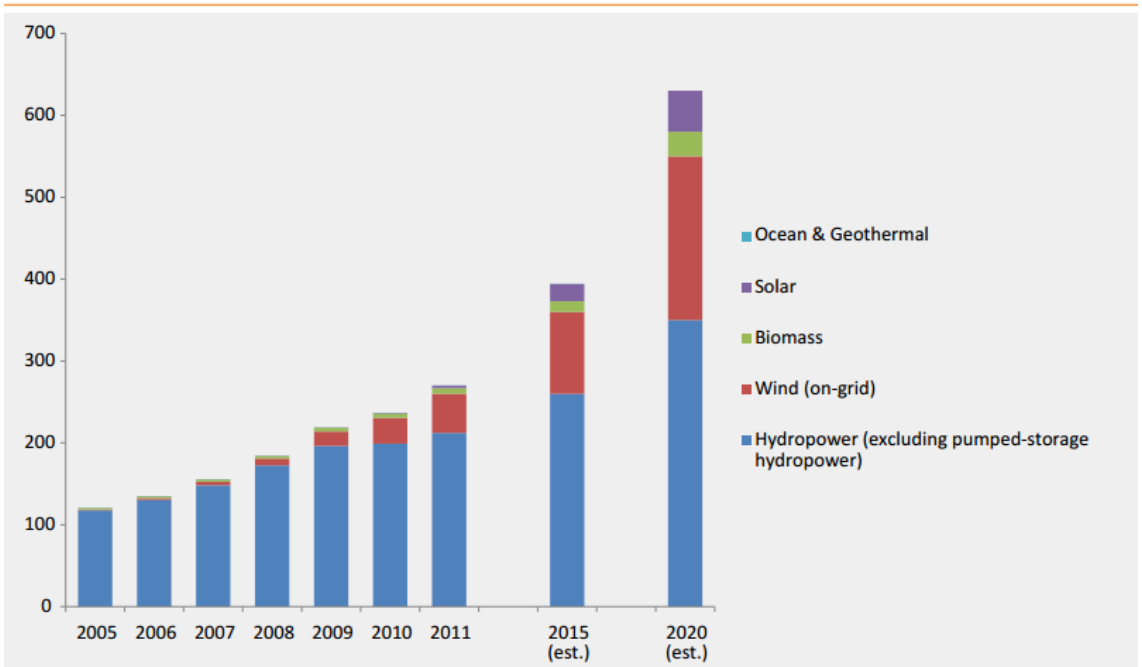
Overview

- **Background and challenge:**
  - uncertainty of contribution of the renewable energy quota system into China's power sector
- **Objective:**
  - analyzing the impact of renewable energy quota system on China's power sector
- **Methodology:**
  - Capacity expansion modelling tool (China Power Planning Model – CPPM)
- **Results and next steps:**
  - Supporting policies and decision making processes

Renewable energy deployment in China

- China is the world leader of renewable energy development:
  - Rapid installation and increasing penetration in energy supply
  - Ambitious national target: **600 GW in 2020**
- This target has led to two issues for China: (i) roadmap for RE development and (ii) policies to support implementation

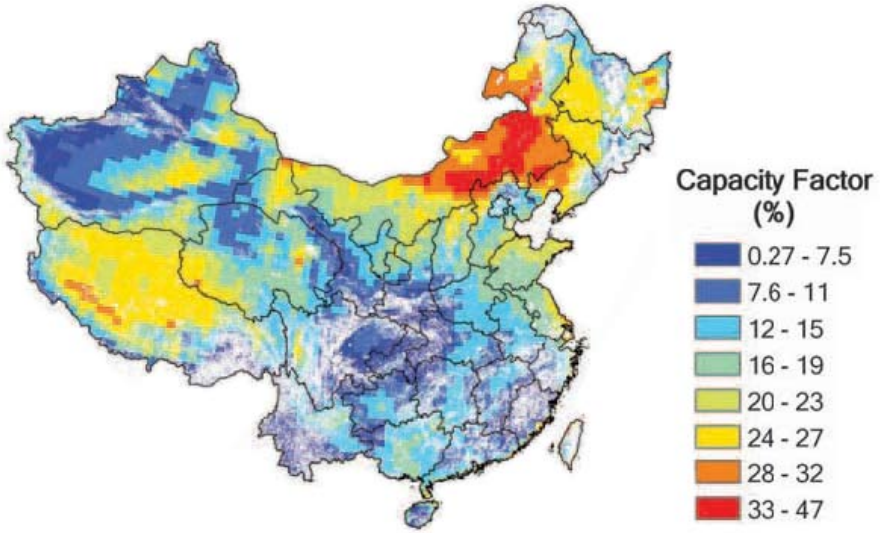


Source: CNREC, 2012

Regional heterogeneity of renewables in China

- Large **heterogeneity** of renewable energy resource and electricity load in China
- Grid integration issues in renewable energy resource-rich regions have occurred in recent years (example onshore wind integration)

→ **Regionally heterogeneous supporting policies are needed**



Wind capacity factor estimation in China

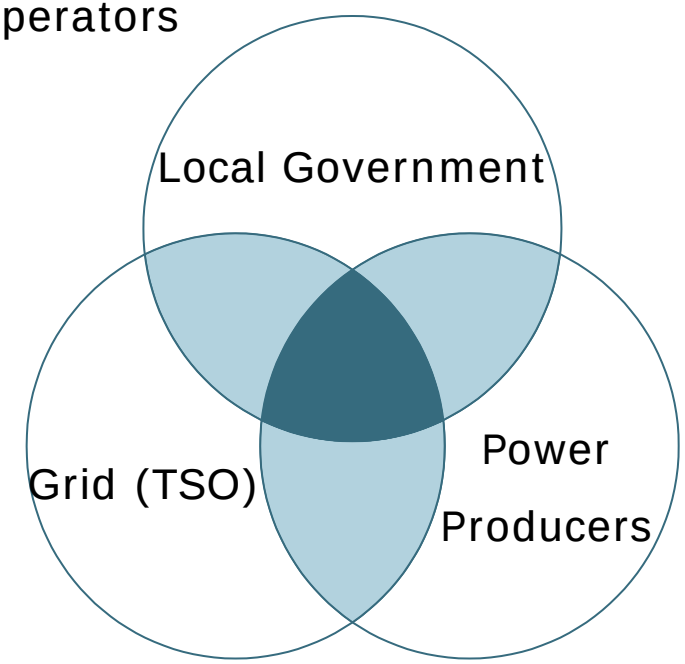
Light pollution from China's cities

Data sources: Harvard, 2010/ Nasa 2010

How to implement a renewable energy quota system for China's power sector?

- Renewable quota system is being considered as main policy tool to guide renewable energy development in China after 2015
  - → Requires grid companies to transmit up to 15% of their power from renewable sources

- Renewable energy targets will be set for provincial governments, power companies and grid operators



What results do existing studies provide for RE policy modelling on China's power sector?

- **Bottom up modelling**
  - Impact of carbon tax policy on power mix to 2050 (Zhang, 2012)
  - Critical effects of CCS on emission to 2030 (Chen,2010)
  - Reduction potential of IGCC (Cai,2007)

- **Top-down economic modelling**
  - Impact of renewable portfolio standards on energy security (Fan, 2005)
  - CCS investment risk by real option modelling (Zhu, 2011)
  - Interaction between electricity/coal price by CGE (He, 2010)

- **Research gap:**
  - **Technical-rich bottom up model including various renewable energy (resource heterogeneity, variation, technology improvement…)**
  - **Muti-regional definition to describe China's power sector**

Our research questions

- There is a need to analyse and discuss potential impact of renewable quota policy on China´s power sector
- Research questions:
  - **What's the potential impact of renewable quota system on emission, generation, installation and transmission for different regions in China?**
  - **What are potential synergies between renewable energy quota and other implemented or on-going policies like carbon cap or feed-in-tariffs?**

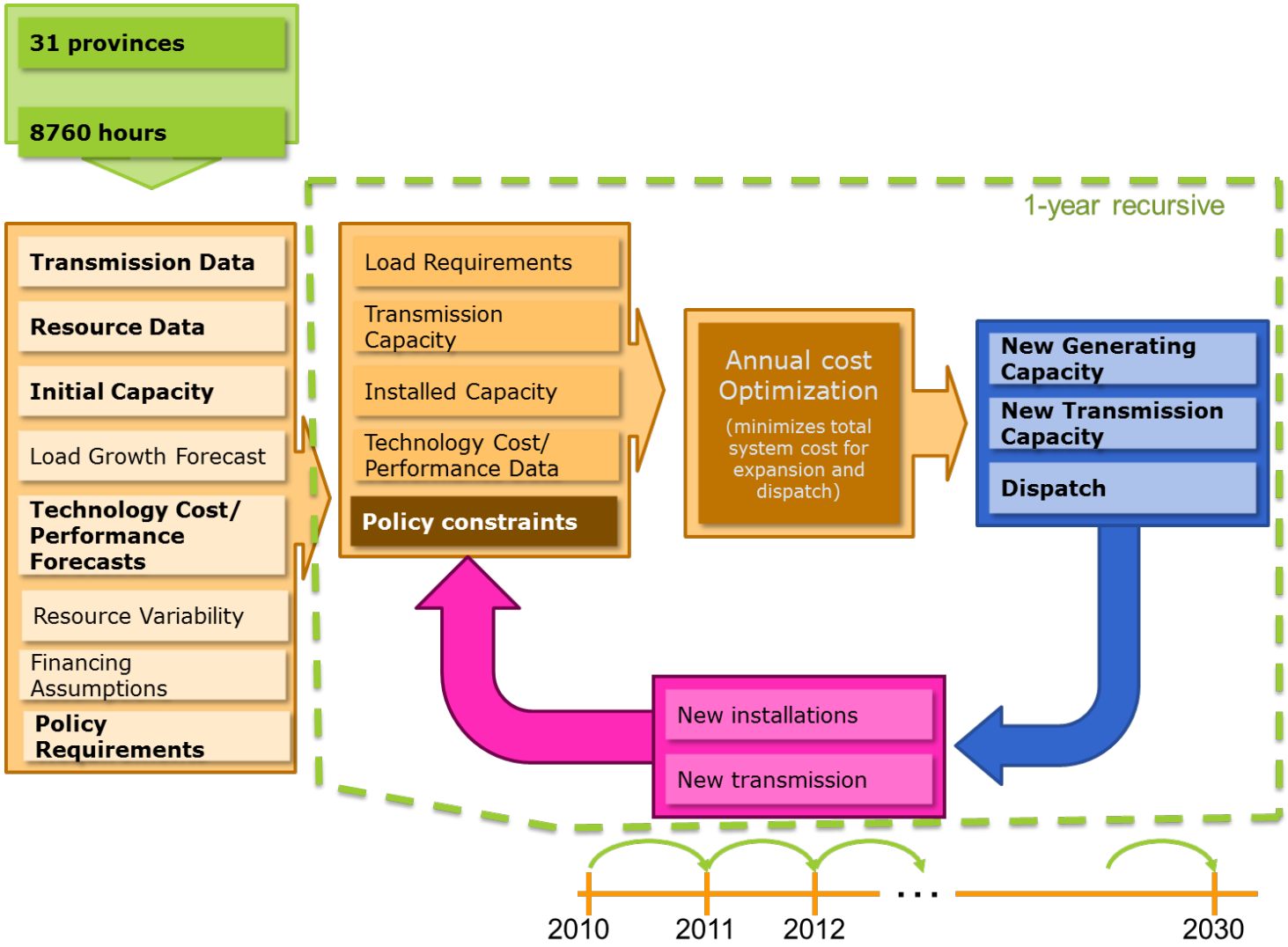
Methodology: Capacity expansion modelling tool

- Capacity expansion model for China's power sector based on open-resource model **Balmorel** was developed
  - Balmorel is widely used in Scandinavian countries
  - 31 provinces for China with updated Chinese data for existing power system
  - Resource potentials for renewables

  → **Finds the minimized-cost solutions for generation and transmission capacity expansion in different regions in China**

- This model can provide information for:
  - Deployment (quantity and location) of each technology/ transmission capacity
  - Cost and emission of each scenario
- … but it can't give details about:
  - Dynamic (frequency, voltage stability, etc.) issues
  - Individual power plant analysis/ distribution level requirement

Methodology: Capacity expansion modelling tool



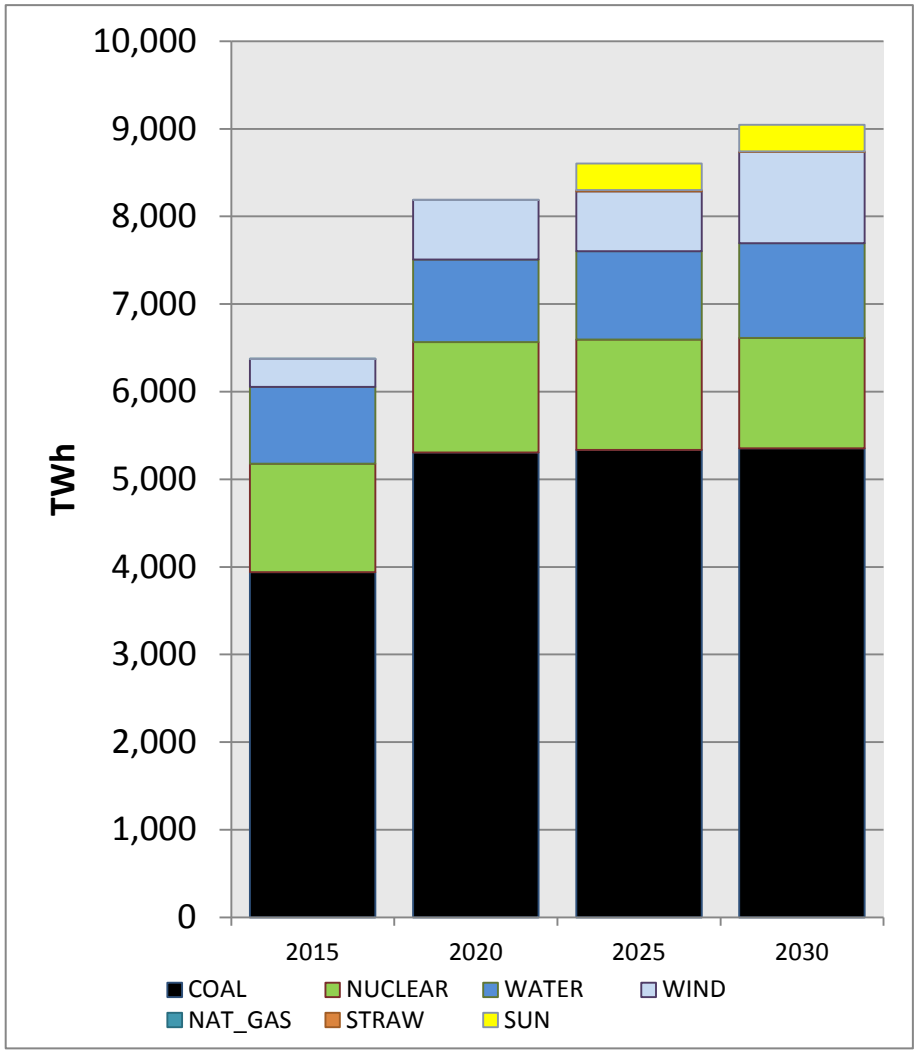
Methodology: Capacity expansion modelling tool

- Muti-scenario analysis:
  - Two renewable quotas scenarios: 15% and 25% non-hydro renewable energy penetration in 2030
  - Two associated carbon cap scenarios with same emission mitigation effect as in 15% quota and 25% quota scenarios

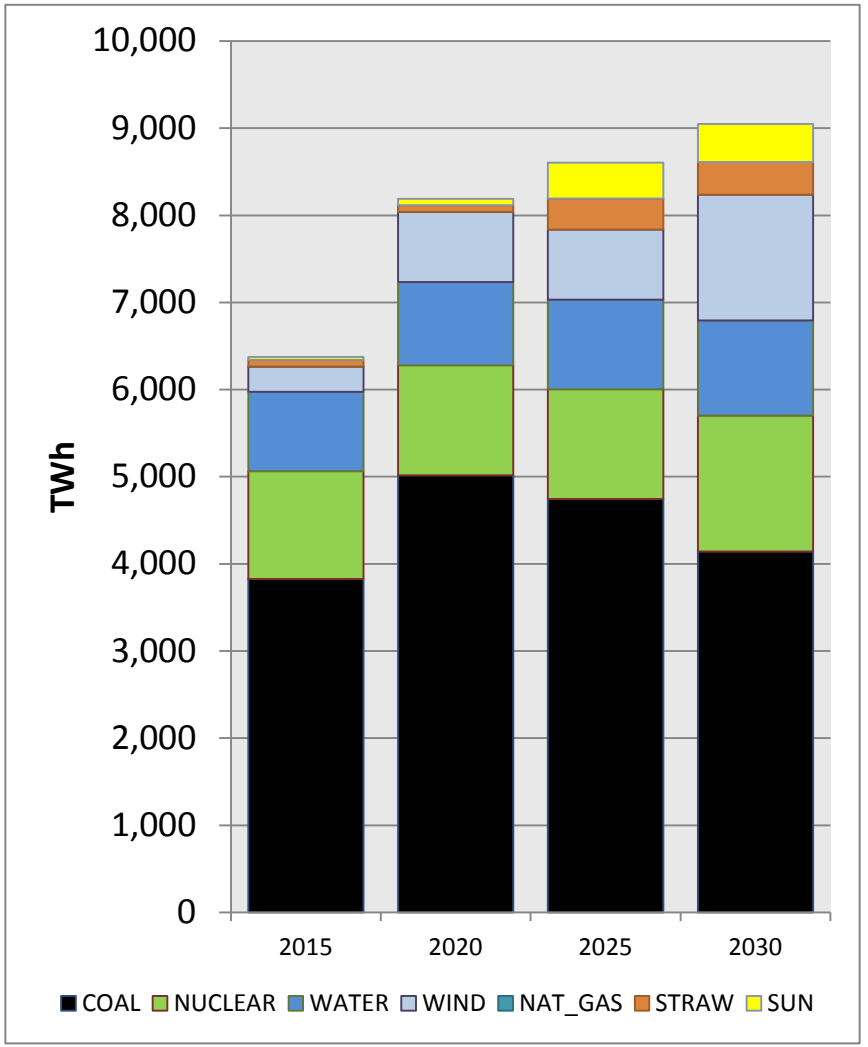
- Key assumptions and database:
  - Coal (sub-criticial, super-criticial, ultra_supercritical, IGCC), coal with CCS, natural gas (turbine, engine, IGCC), renewable energy (wind onshore, wind offshore, solar PV,CSP, hydro, small hydro, pump hydro)
  - Technology performance and cost: investment cost, O&M cost, efficiency…
  - Electricity demand: **provincial forecast from CAS and State Grid**
  - Grid connections: aggregation of transmission capacity among provinces, cost matrix for new connections

Results: Future electricity generation under different RE quotas

15%_quota generation



25%_quota generation

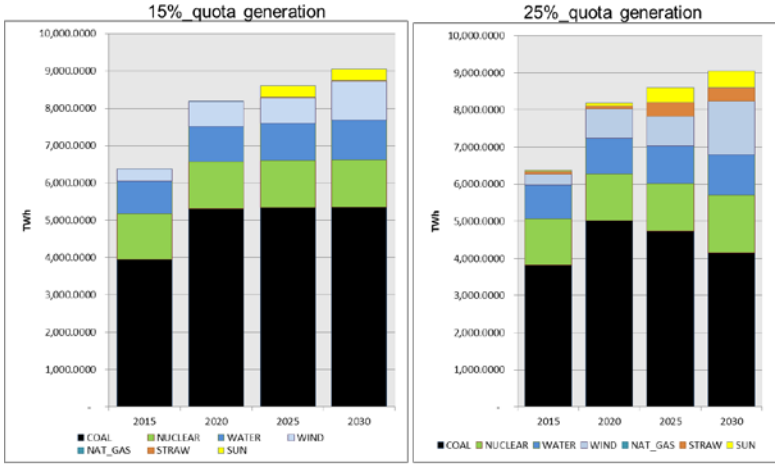


Results: Future electricity generation under different RE quotas

In the short term (2010-2020)

– No significant differences between two scenarios

– No large scale biomass and solar energy deployment



In the long term (2020-2030) → differences between scenarios increase

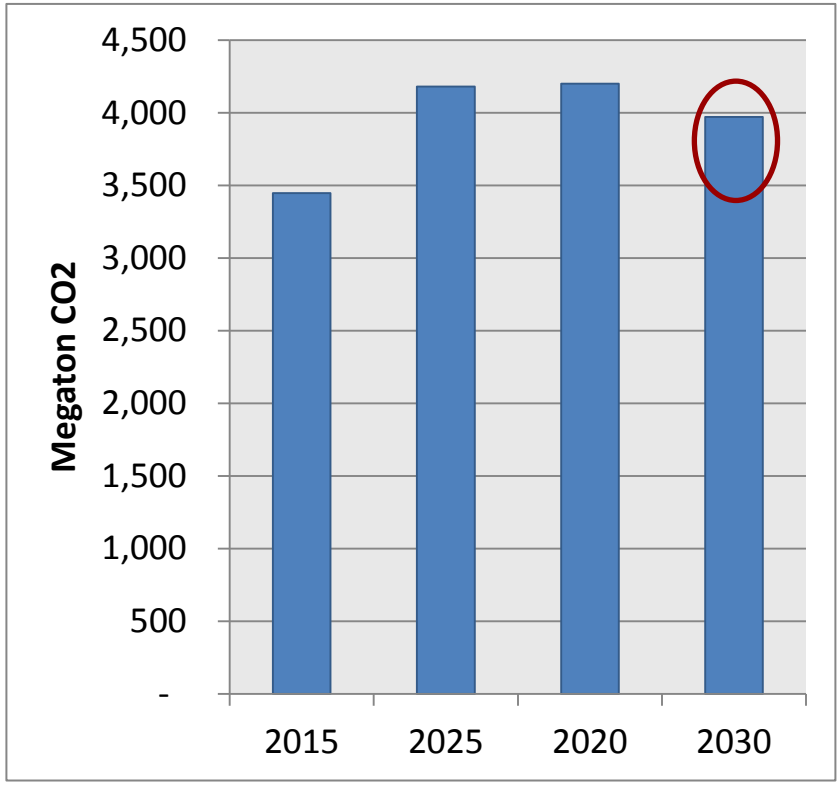
– The coal remains major fuel for power generation in 15%_quota scenario --- but **coal generation decreases very rapidly in 25% scenario after 2015**

– There is no obvious development of biomass energy and solar energy in 15% scenario ----but **the 25% quota scenario drives significant renewable generation**, particularly for wind power, after 2020.

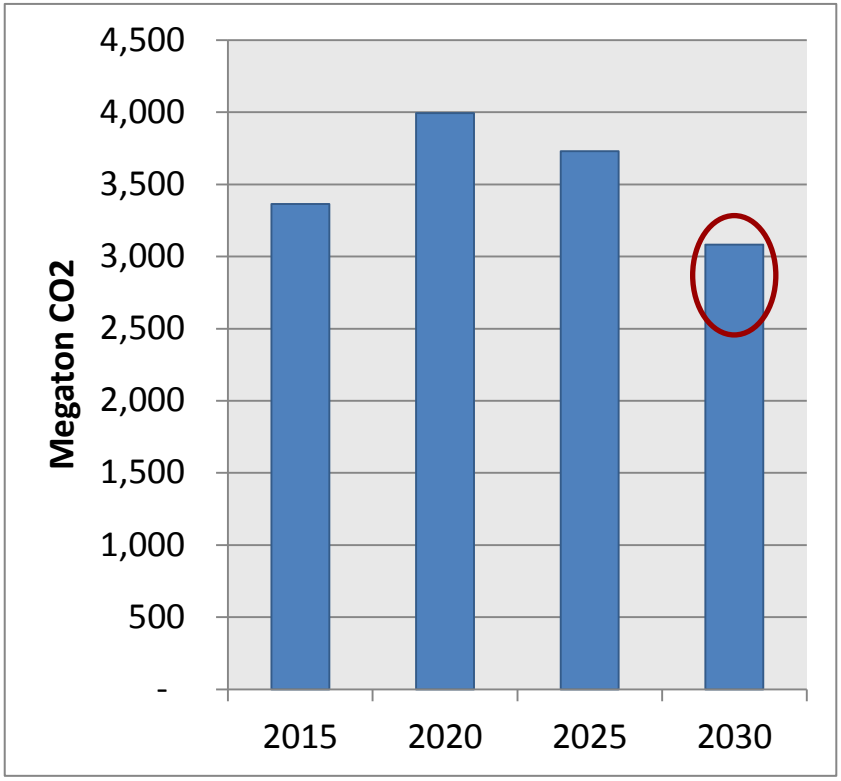
Results: CO_2 emission mitigation under different RE quotas

- Key results:
  - **15% quota scenario fails to reduce carbon emissions drastically** and emission peak is one decade later than in the 25% quota scenario
  - **25% quota shows less emissions in 2030 compared to 2015**

15%_quota carbon emission



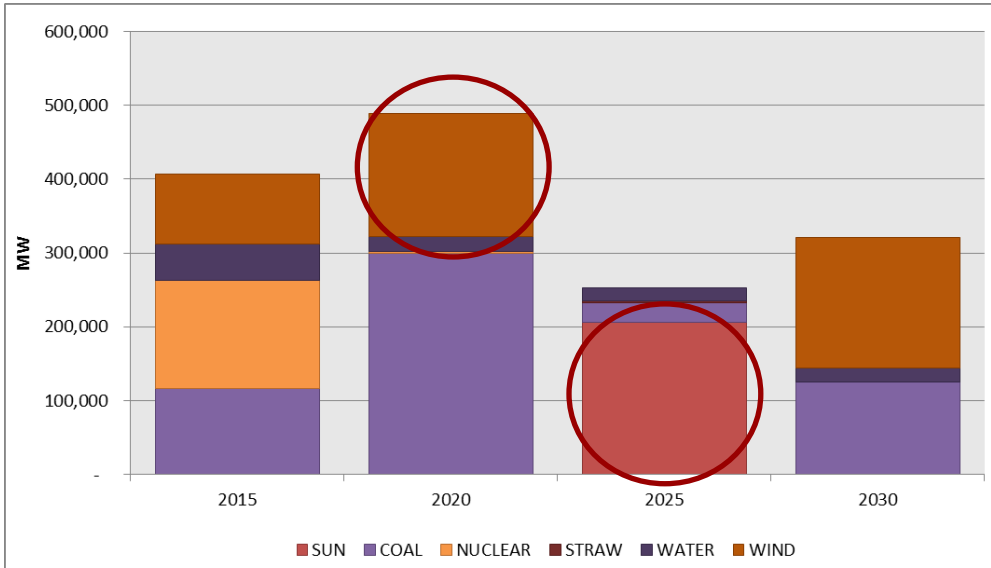
25%_quota carbon emission



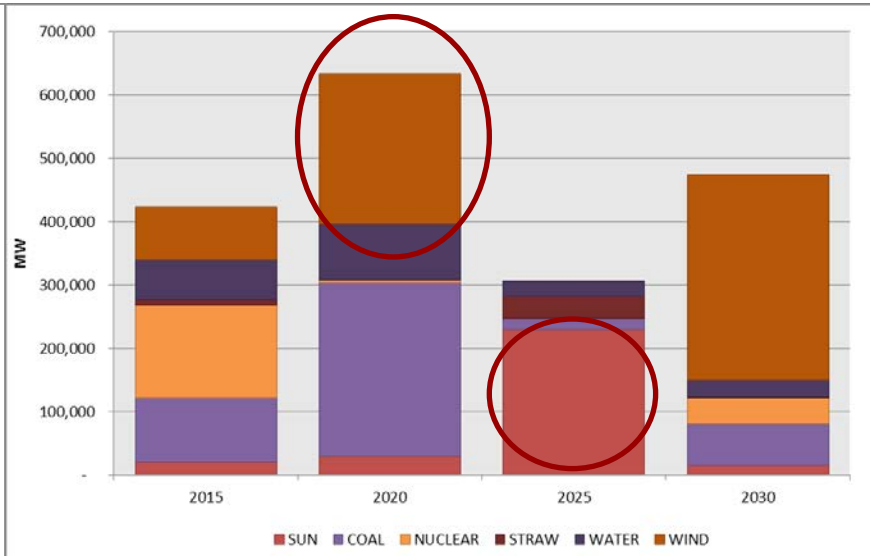
Results: New investments in power generation capacity under RE quota scenarios

High quota needs more investment capacity on renewable energy,

- especially wind energy in short term and
- solar energy in the long term



15%_quota capacity investment

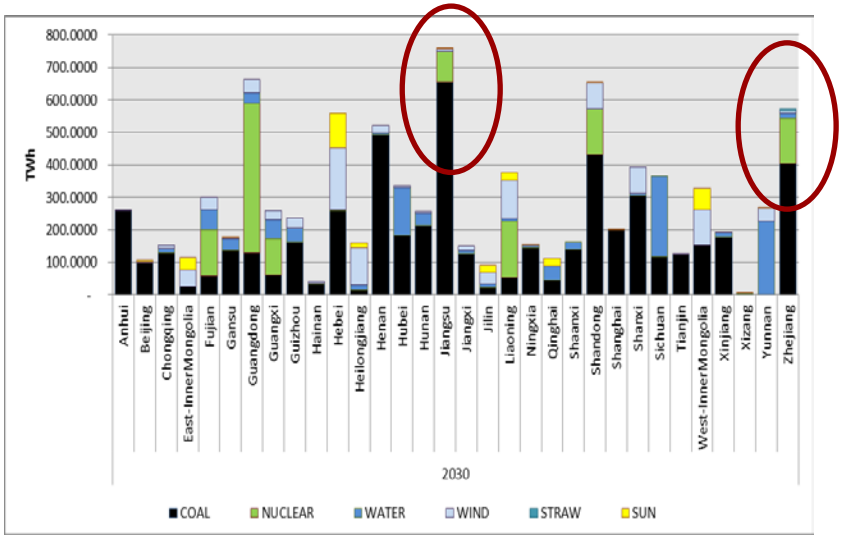


25%_quota capacity investment

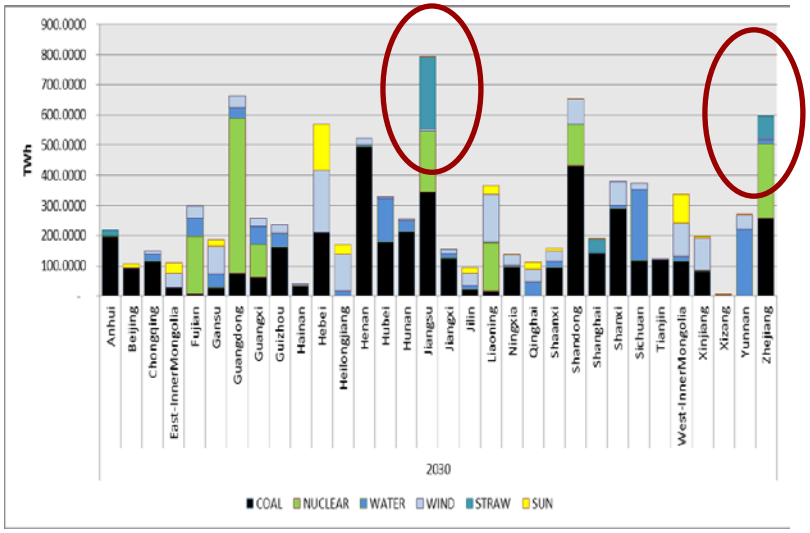
Results: Provincial heterogeneity of RE deployment under different RE quota scenarios

- Share of renewable energy varies among provinces in both scenarios
- The renewable energy penetration has strongly relationship with renewable resource and domestic fuel prices, especially coal price
- High quota is needed for biomass energy

15%_quota generation mix



25%_quota generation mix

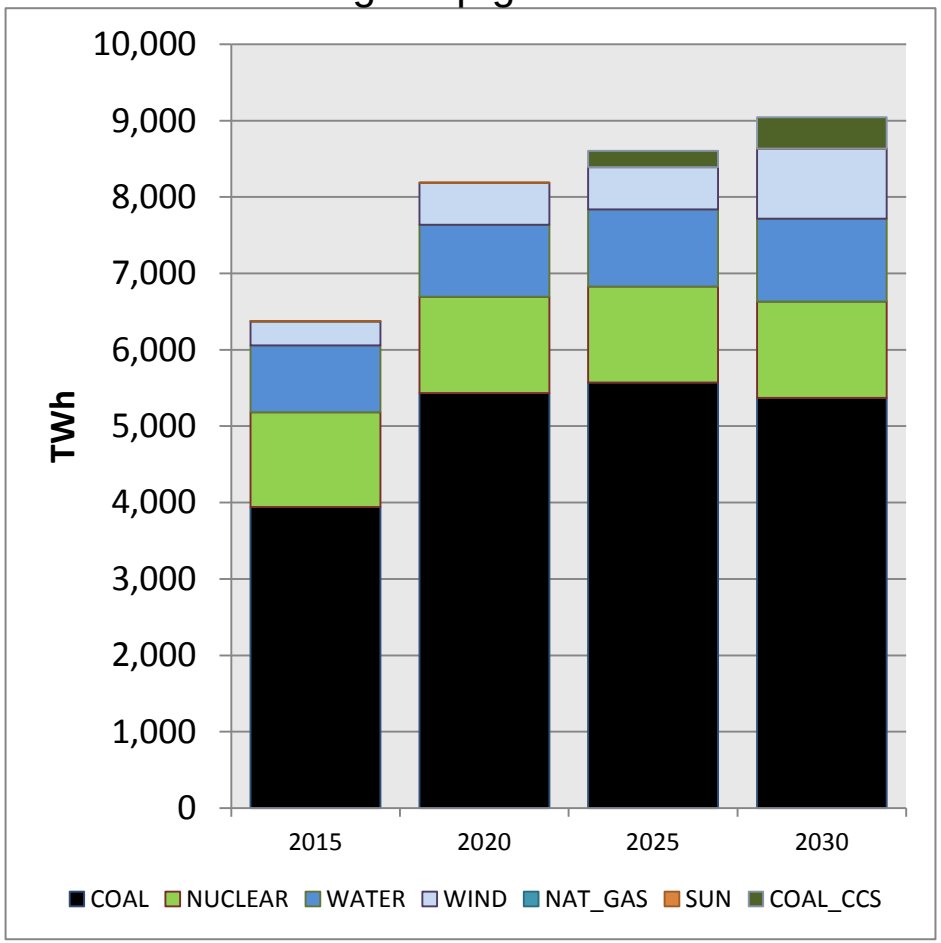


Results: High and low carbon cap scenarios

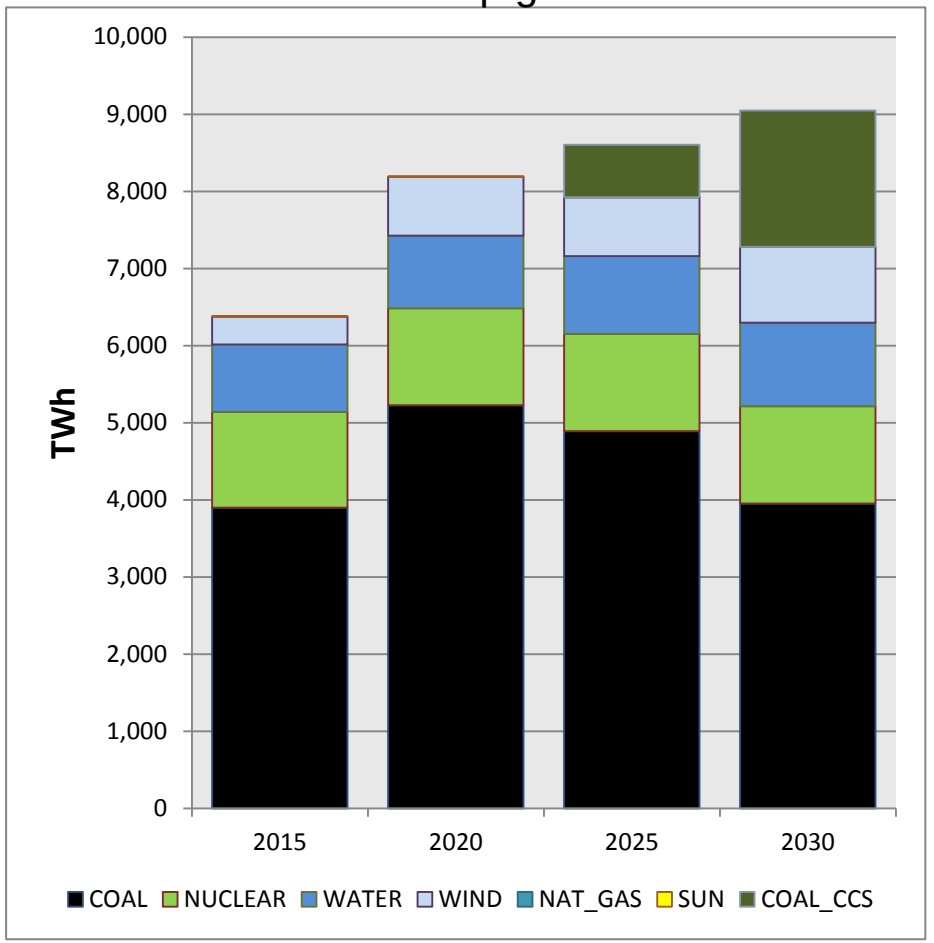
High cap scenario: same carbon emissions set as in 15% quota scenario

Low cap scenario: same carbon emission set as in 25% quota scenario

High cap generation



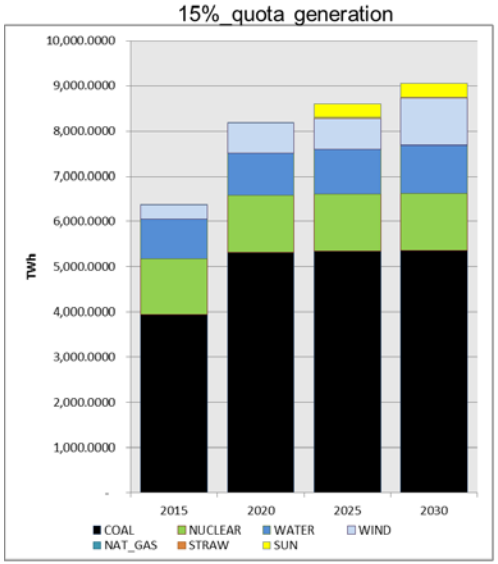
Low cap generation

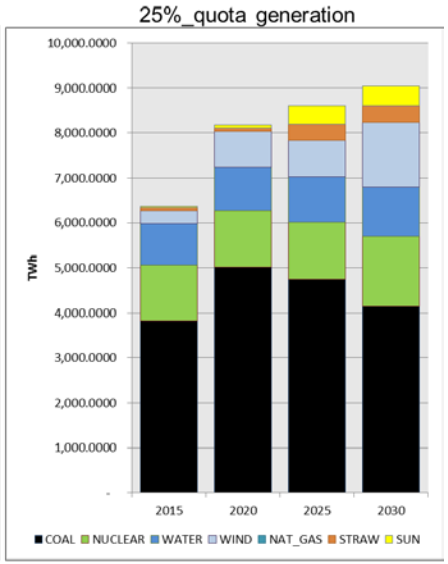


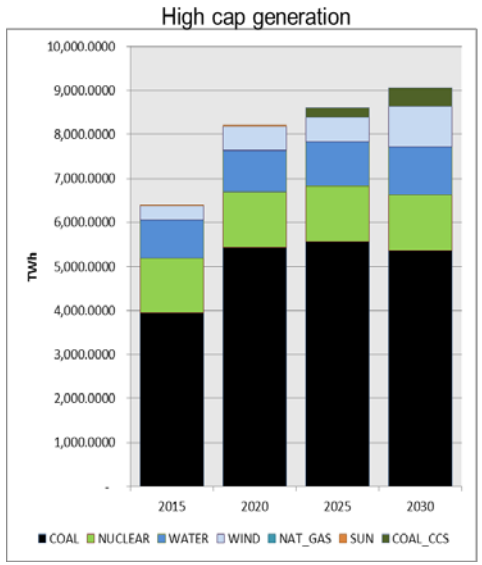
Results: Comparison of RE quota and carbon cap scenarios

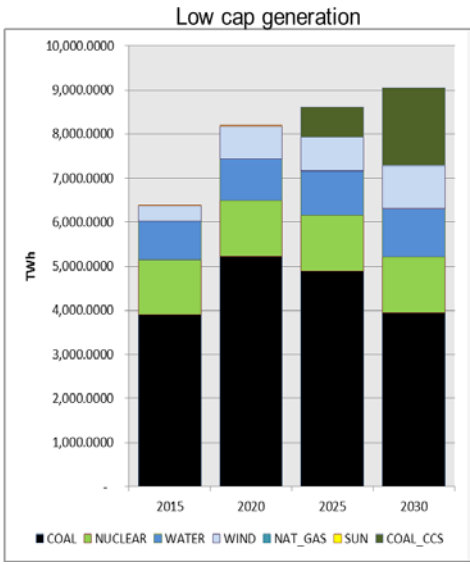
the power generation mix in the short term (2010-2010) is similar in quota scenarios and cap scenarios

technology neutral carbon cap scenarios stimulate the development of CCS rather than biomass and solar energy









Key conclusions

- Renewable energy quota could drive the development of renewable energy in China very significantly
- **Different quotas have obvious discriminative influence on different renewable energy technologies**
- Carbon cap policy could reach the same target of emission mitigation while **coal+CCS** would be the key mitigation option than renewable energy in the long term
- **The optimal renewable energy penetration modelled varies among provinces**

  → regional targets or green certificates trading are needed in China's quota policy

Next steps

- Data improvements for different regions, Integration of more experts' forecast
- Sensitivity analysis of key parameters
- Development of the current model into a standard modelling platform to discuss China's policies for the power sector
- Model innovation in the future:
  - Renewable energy resouces: integration with high-resolution GIS analysis
  - Supply curve of renewabe energy resouce and fossil fuels
  - Reflect the impact of wind/solar intermittences on the overall power sector

Collaboration and contacts

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